LAI and *f*APAR validation under CEOS/LPV-VALERI

Landscape spatial patterns and the VALERI sampling strategy

The Shandan (CH) and Gilching (D) cases

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VALERI Objectives, developments

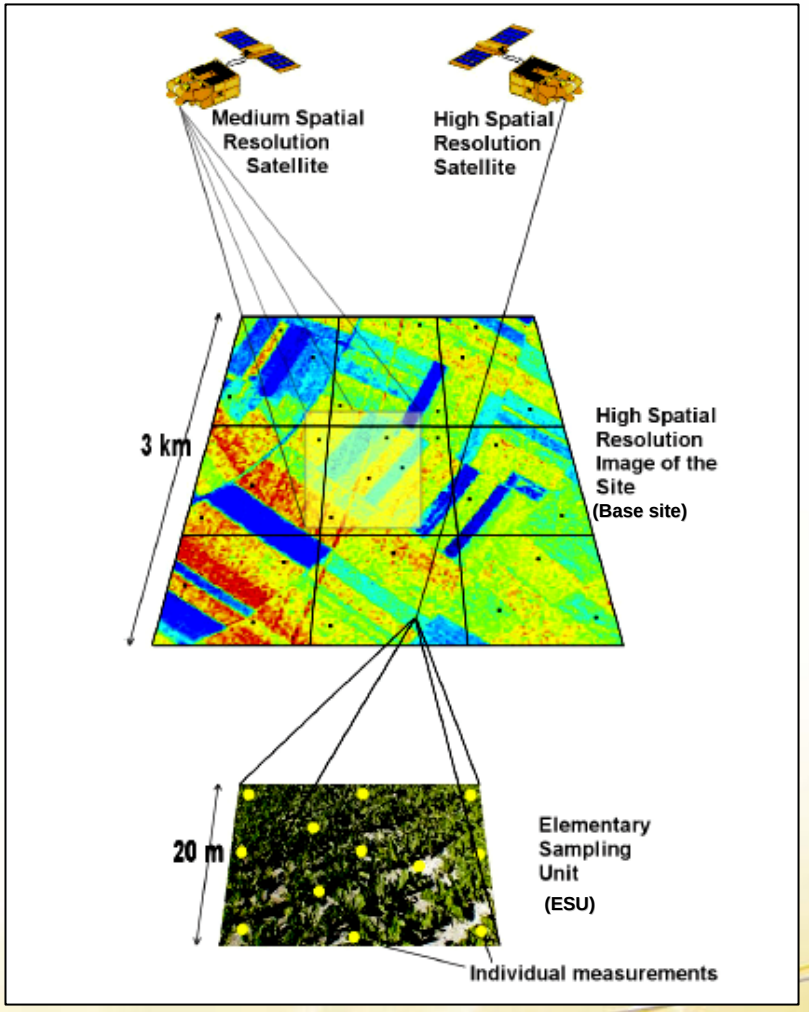
The objectives of the VALERI project:

- **To evaluate the absolute accuracy of bio- geophysical products (LAI, *f*APAR, *f*Cover) derived with a range of algorithms from large IFOV sensors (e.g. AVHRR, POLDER, VEGETATION, SEAWIFS, MSG, MERIS, AATSR, MODIS, MISR,…).**
- **To inter-compare products derived with different sensors and algorithms.**

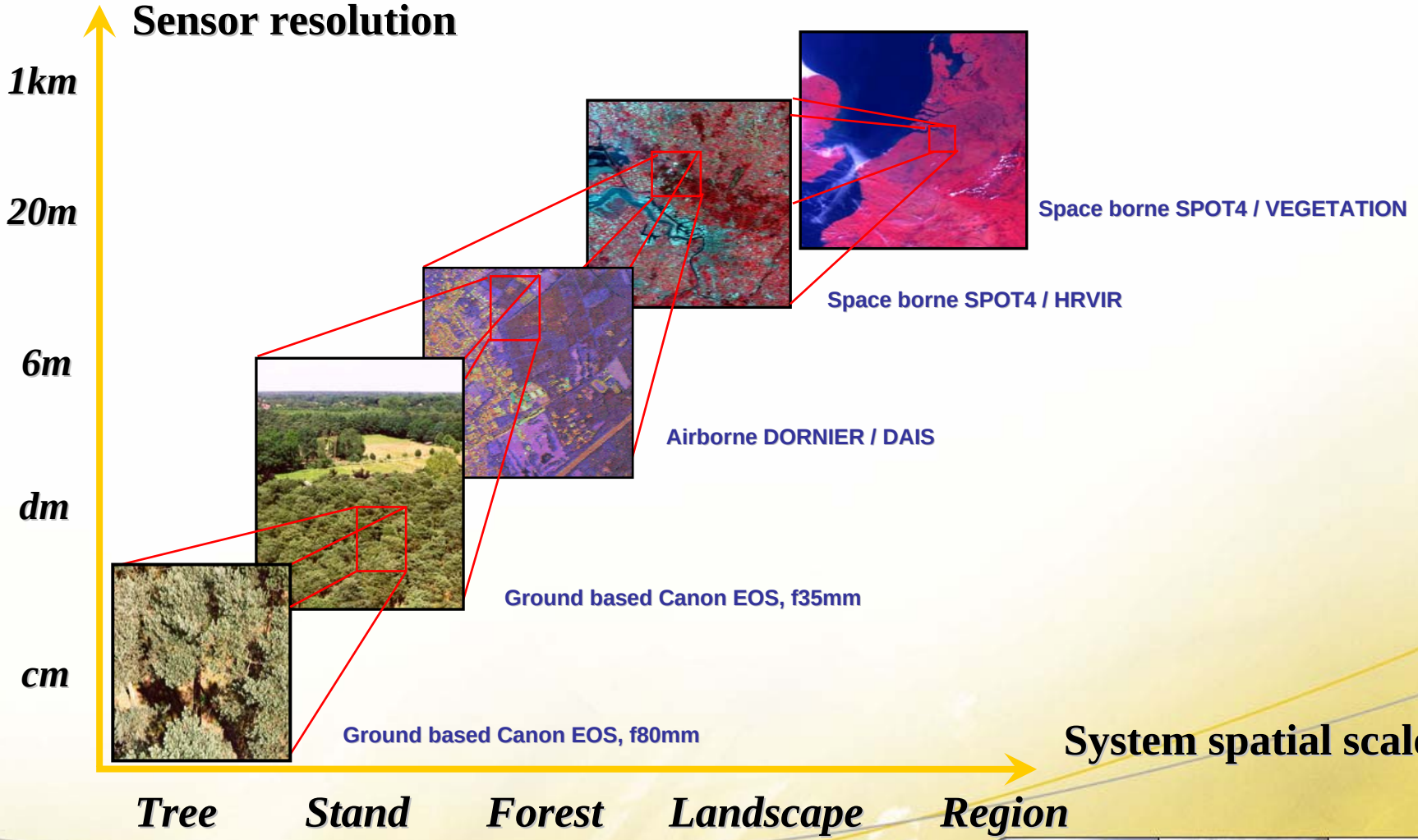
For this purpose, the VALERI project develops:

- **A network of sites distributed globally.**
- **A standard methodology designed to directly measure the bio-geophysical variables of interest at the proper spatial and temporal scales.**

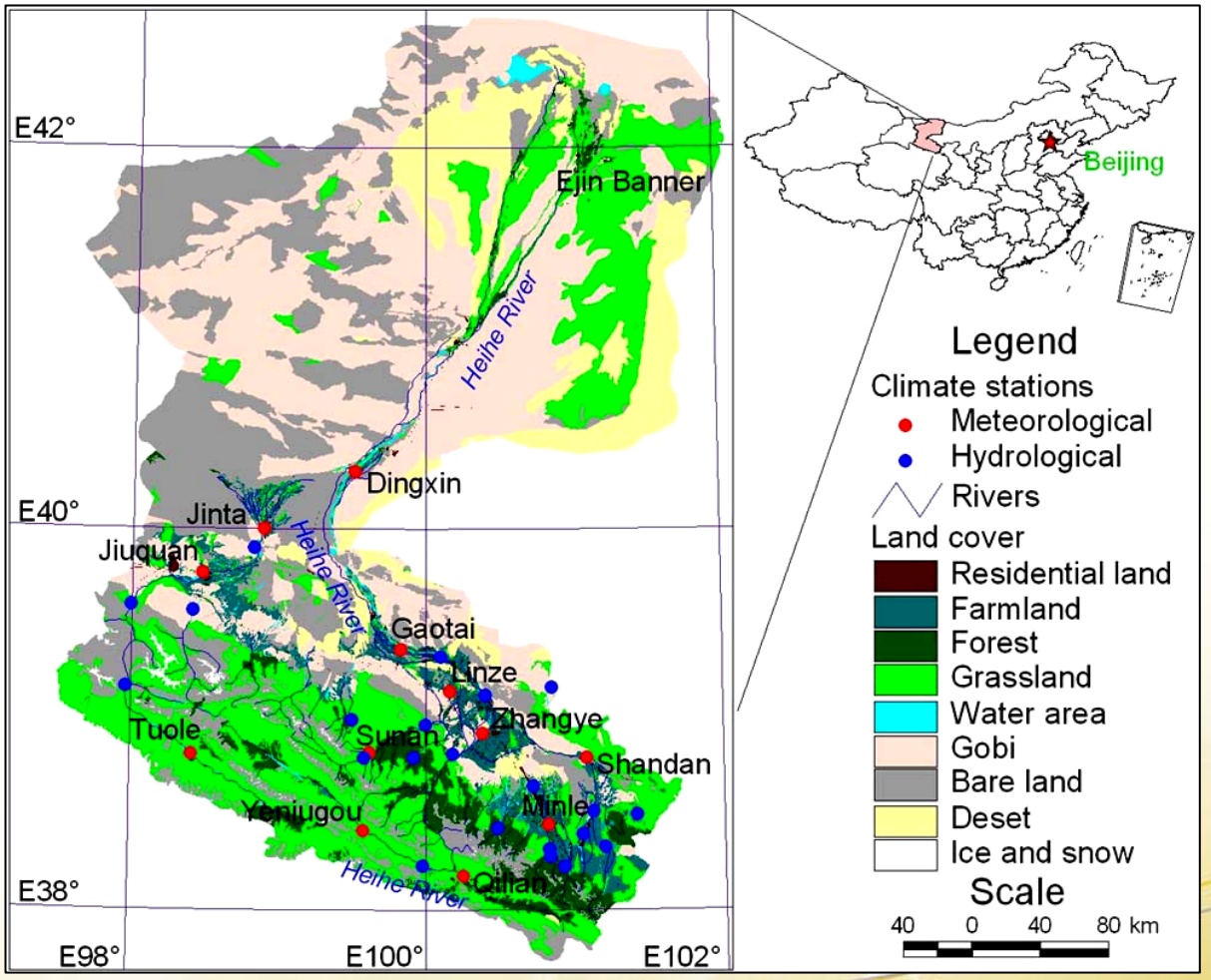
Up-scaling strategy



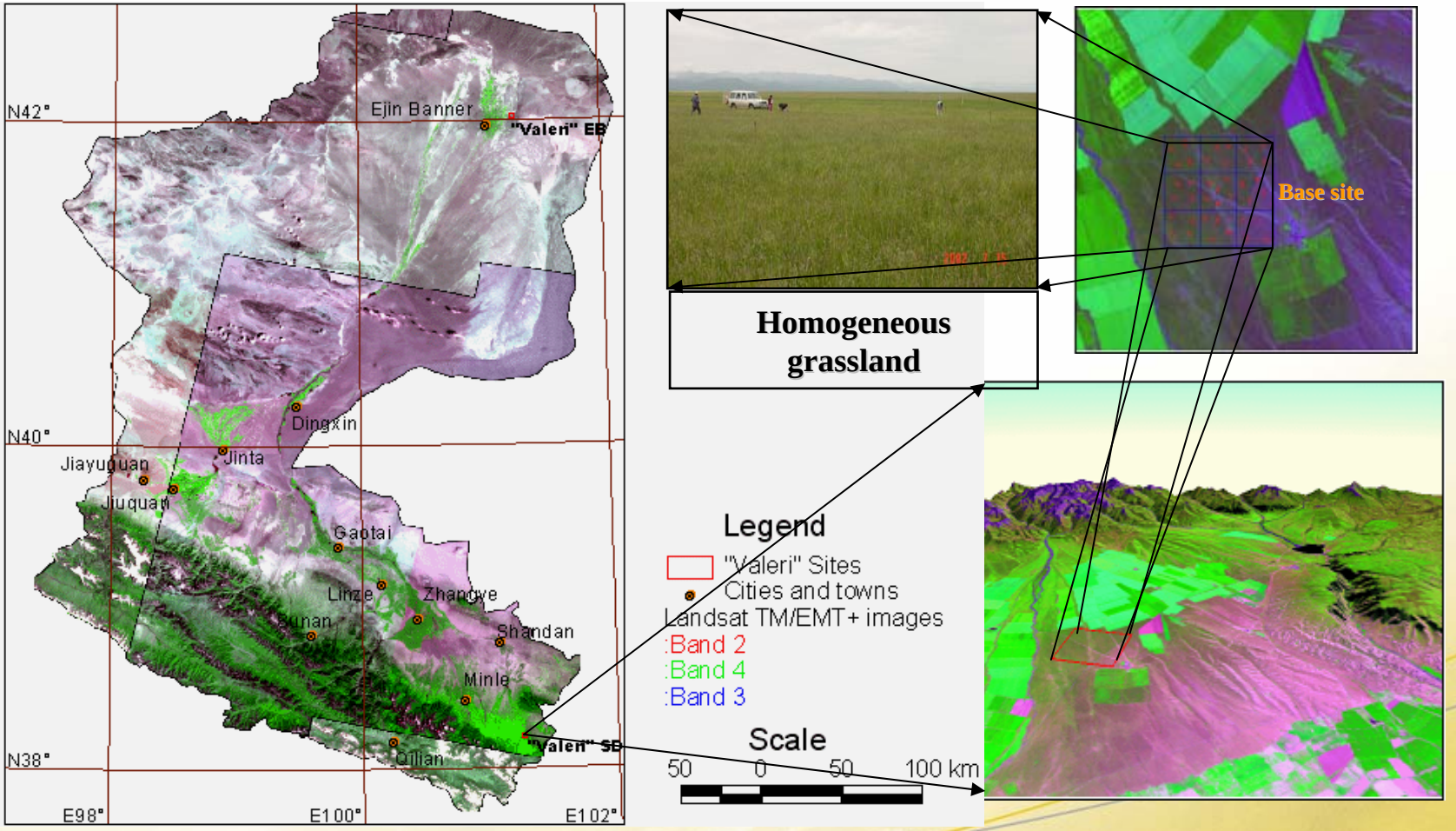
Spatial scale



The VALERI Shandan site (Gansu province, CH)



The VALERI Shandan site



VALERI spatial sampling strategy in a homogeneous landscape

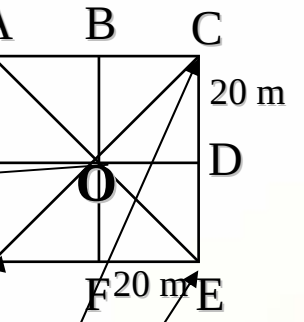
Sampling in 37 ESU's of 20 m²

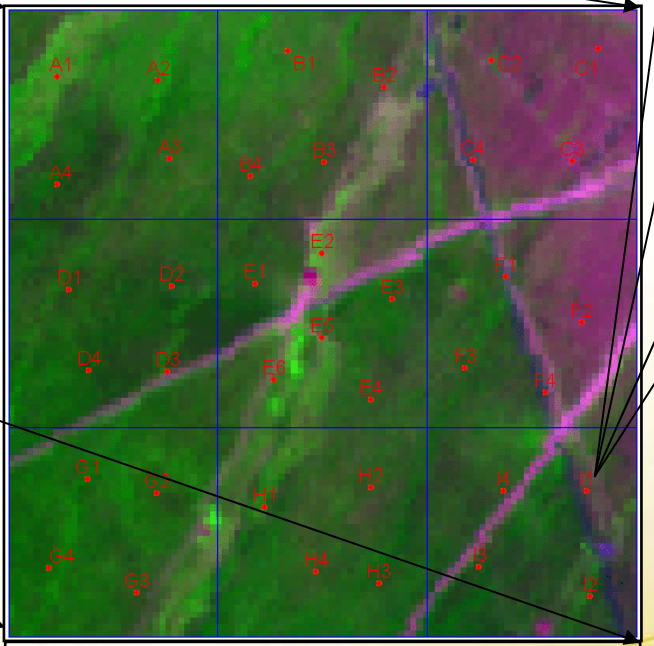
3 km

3 km

ESU(x,y)

Trimble Geo-Explorer





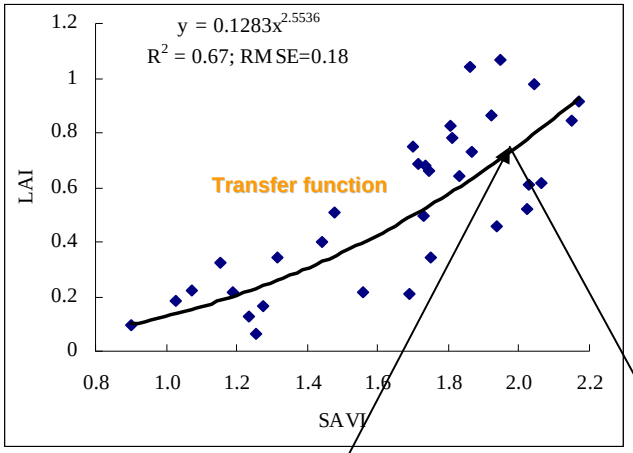
Landsat ETM+ RGB false-colour for the Shandan site

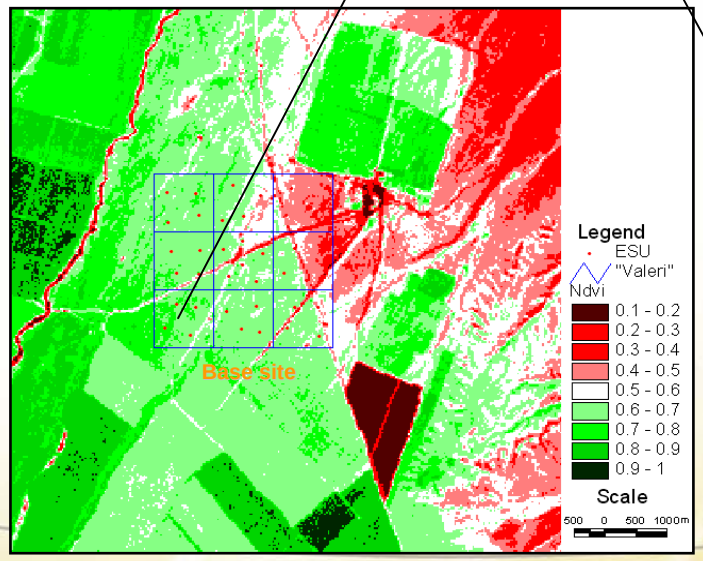
ESU(x,y) = *f* (Randomness)

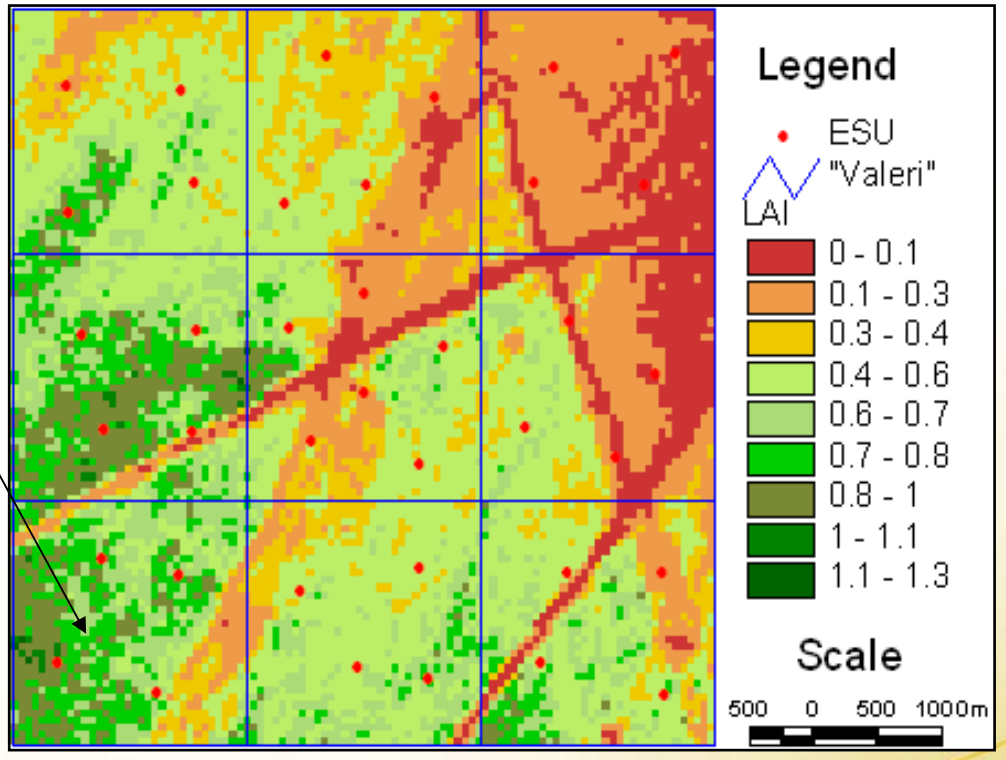
VALERI spatial sampling strategy in a homogeneous landscape

- Each 3 km² base site contains a number of randomly positioned and rotated 20 m² ESU's.
- The angle of ESU line FB with the true North is chosen randomly.
- Each 1 km² pixel in the base site has 4 ESU's. The central pixel has 5 ESU's.
- In each 20 m² ESU, discrete bio- geophysical variables measurements take place at nine points (A, B, C, D, E, F, G, H, O).
- In each 20 m² ESU continuous biophysical variables measurements take place along eight lines (AC, CE, EG, GA, AE, CG, BF, HD), or according to the sun's position.
- The ESU centre point (O) is determined with a Trimble Geo-explorer 2 GPS. All other ESU measuring points co-ordinates are thereby determined.
- Only one single transfer function for the whole base site is required.

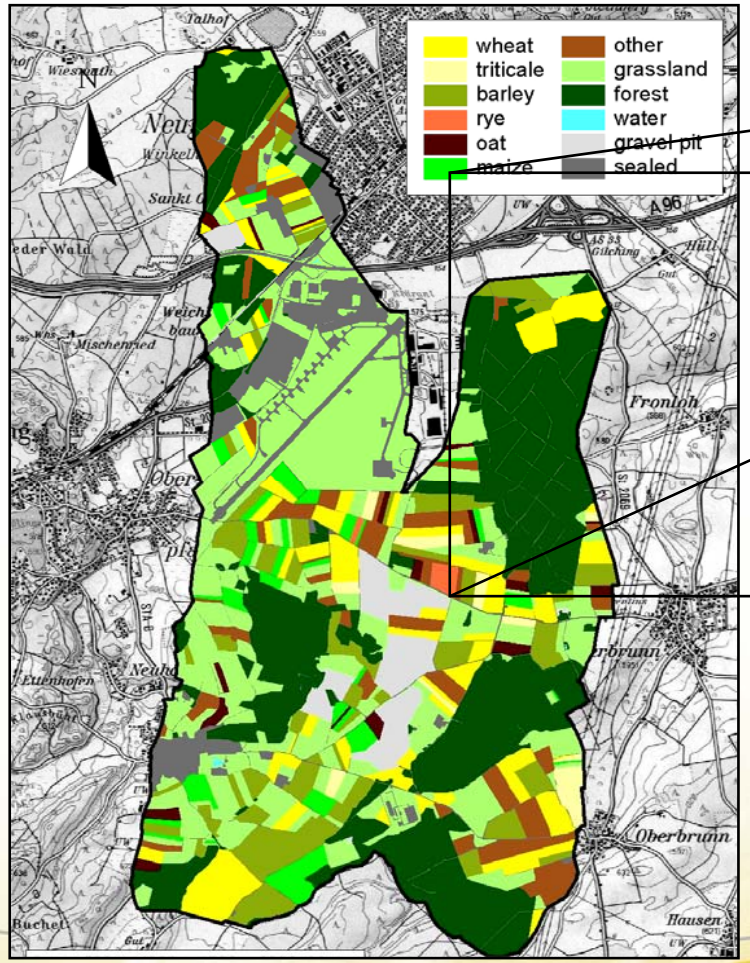
Example of LAI up-scaling with ETM+ SAVI



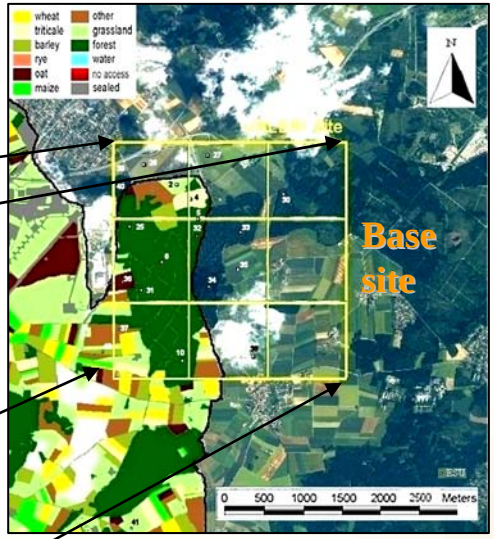




The VALERI Gilching site (Bavaria, D)



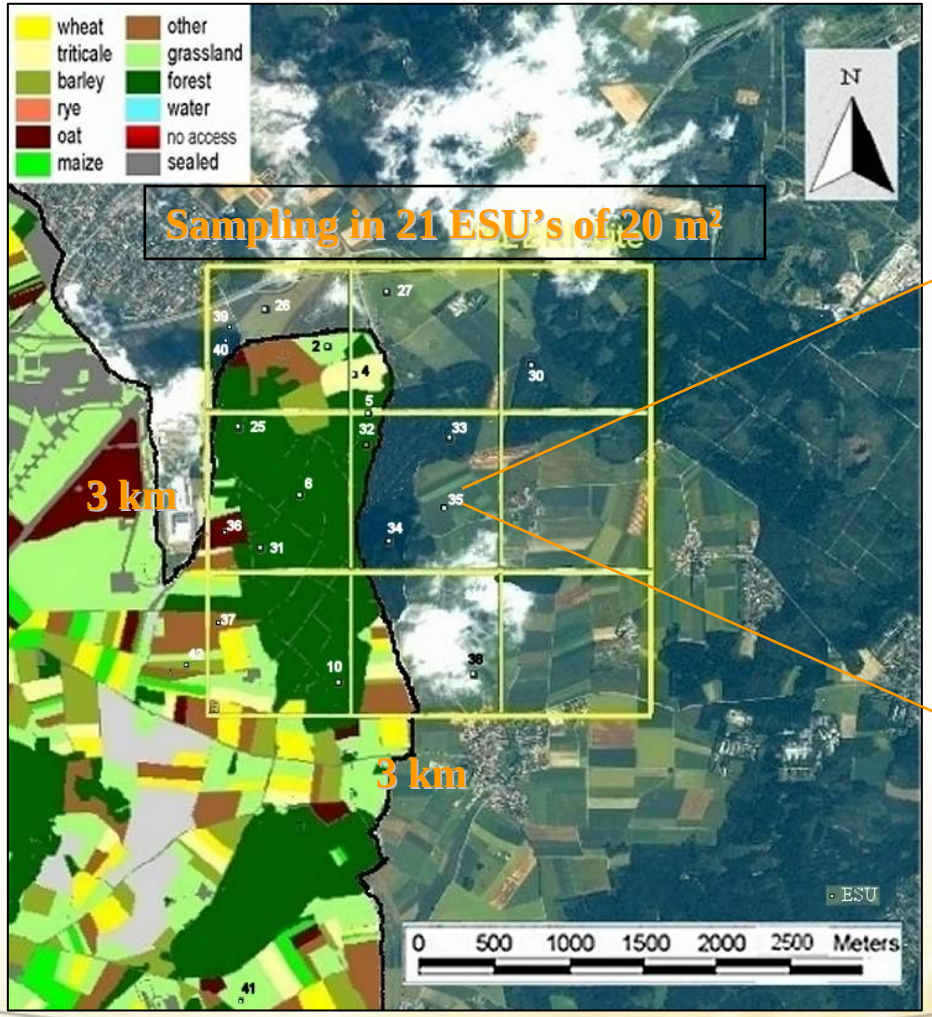
3 km



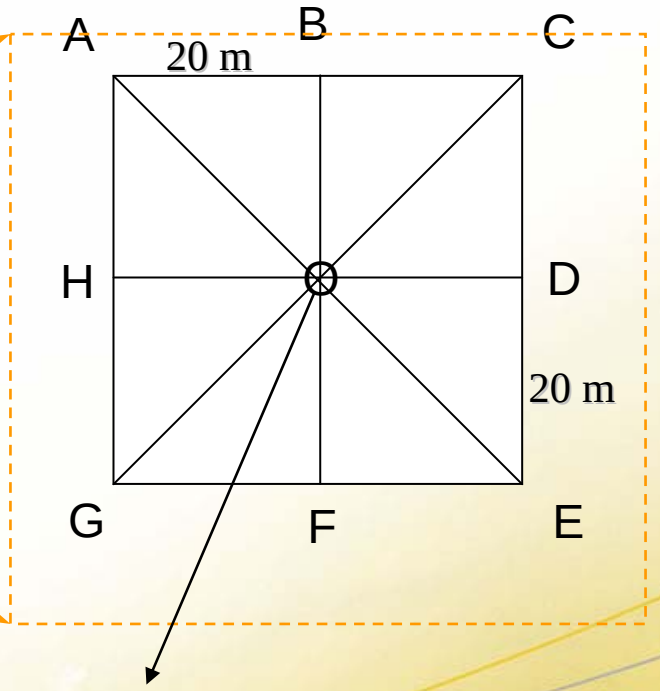
3 km

'European' patchy landscape

The VALERI Gilching site (Bavaria)



ESU(x,y) = *f* (landcover)



Trimble GeoExplorer → **ESU(x,y)**

VALERI spatial sampling strategy in a heterogeneous landscape

- Each 3 km² base site contains a number of 20 m² ESU's positioned according to landcover type.
- The angle of ESU line FB with the true North is chosen randomly.
- Each 1 km² pixel in the base site has a number of ESU's according to the number of different landcover type patches.
- In each 20 m² ESU, discrete biophysical variables measurements take place at nine points (A, B, C, D, E, F, G, H, O).
- In each 20 m² ESU continuous biophysical variables measurements take place along eight lines (AC, CE, EG, GA, AE, CG, BF, HD), or according to the sun's position.
- The ESU centre point (O) is determined with a Trimble Geo-explorer 2 GPS. All other ESU measuring points co-ordinates are thereby determined.
- As many transfer functions as land cover types for the base site.

VALERI indirect methods (for LAI)

➢ Indirect methods

✓ Tracing radiation and Architecture of Canopies (TRAC – CCRS)

- ✓ Gap size distribution, *f*APAR, clumping index, effective LAI
- ✓ Continuous measurement in 20 m block (steady pace walks).
- ✓ Dedicated software package from CCRS.
- ✓ Time logging (Sun zenith angle)
- ✓ Cloud free conditions needed.

✓ Hemispherical photography (HDP) (Nikon Coolpix 5000 and fish-eye)

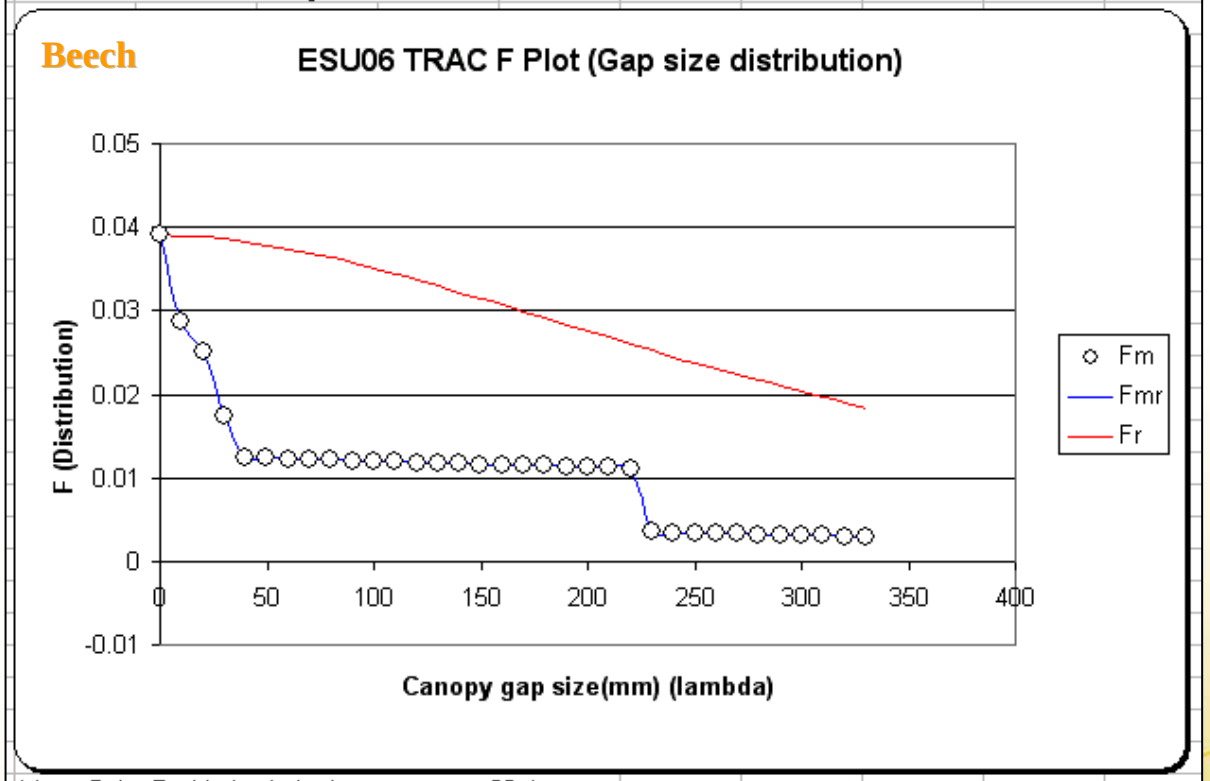
- ✓ Effective and 'true LAI', fAPAR, fCover, clump size index, canopy architecture
- ✓ Software: INRA Avignon software package CANEYE
- ✓ Discrete measurements on 20 m ESU points A,B,C,D,E,F,G,H,O
- ✓ Time logging (Sun zenith angle)
- ✓ Cloud free conditions needed

✓ Licor LAI-2000

- ✓ Measurement of effective LAI
- ✓ Discrete measurements on 20 m block points A,B,C,D,E,F,G,H,O
- ✓ Time logging (Sun zenith angle)
- ✓ Interesting comparisons possible with HDP and TRAC (I. Jonckheere, FEM, 2006)

indirect method (TRAC)

Fm: Non-random canopies like in plantations and natural forests (measured gap size distribution)
Fmr: Gap size distribution after excessive gaps have been removed iterated till a portion of Fmr falls below Fr
Fr: Random case and final solution of F. Assumes canopy with negligible woody material excessive gaps removed and random foliage distribution.



Mean Solar Zenith Angle in the transect = 36.4

PAIe= 5.2 LAI = 4.4	For LAI calculation gaps are removed, so based on Fr distribution.
Ω from data: 53.9 mm	Ω: Foliage typical width

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VALERI indirect method (HDP)

CANEYE

VALERI indirect methods (for LAI)

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VALERI indirect method (LAI-2000)

LAI2000 file lay out and significance of measured and calculated variables

FILE	DATE	TIME	WHAT	WHERE	LAI	SEL	DIFN	MTA	SEM	SMP
17	20-07-02	14:27:47	BEECH	ESU6	3.29	0.11	0.056	41	4	9
ANGLES	7	23	38	53	68					Header
CNTCT#	2.414	2.607	2.531	1.839	1.018					
STDDEV	0.712	0.564	0.218	0.252	0.101		Statistics group			
DISTS	1.008	1.087	1.27	1.662	2.67					
GAPS	0.088	0.059	0.041	0.048	0.067					
1	2	3	4	5	6	7	8			
A	1	14:37:26	137.5	107.1	89.83	71.36	24.43			
B	2	14:39:07	12.21	4.582	3.574	2.772	1.102			
B	3	14:39:19	32.69	10.29	4.873	3.274	1.519			
B	4	14:39:32	10.78	9.6	2.672	8.429	2.889			
B	5	14:39:53	7.318	8.982	5.75	5.39	1.499		Observations	
B	6	14:40:10	37.14	18.24	4.112	2.886	2.162			
B	7	14:40:25	7.734	2.923	3.722	3.348	1.319			
B	8	14:40:37	3.253	4.106	2.149	2.549	1.445			
B	9	14:40:48	10.3	2.556	3.442	1.881	1.43			
B	10	14:41:01	18.16	6.968	3.551	2.892	1.736			

Header			
FILE:	file number		ANGLES: Angels of the concentric circles for which the LAI measurement is performed
DATE:	date dd/mm/jj		CNTCT# Mean contact frequencies (the log of transmittance divided by by path length
TIME:	time hh/mm/ss	Statistics group	STEDDEV: Standard deviation on the number of contacts
WHAT:	Vegetation type		DISTS: Path length (for full cover canopies = 1/cos(ANGLES)
WHERE:	Elementary Sampling Unit Number		GAPS: Gap fraction
LAI:	Leaf Area Index		
SEL:	Standard Deviation on LAI		A: Reference measurement outside the vegetation plot (or above)
DIFN:	Fraction of the sky visible beneath the canopy		B: Measurement below the vegetation canopy
MTA:	Mean leaf Tilt Angle	Observations	Column 2: Measurement number
SEM:	Standard deviation on MTA		Column 3: time hh/mm/ss
SMP:	Number of pairs of above and below observations used to calculate results		Column 4-8: Observations (Signals of the 5 rings of the detector)

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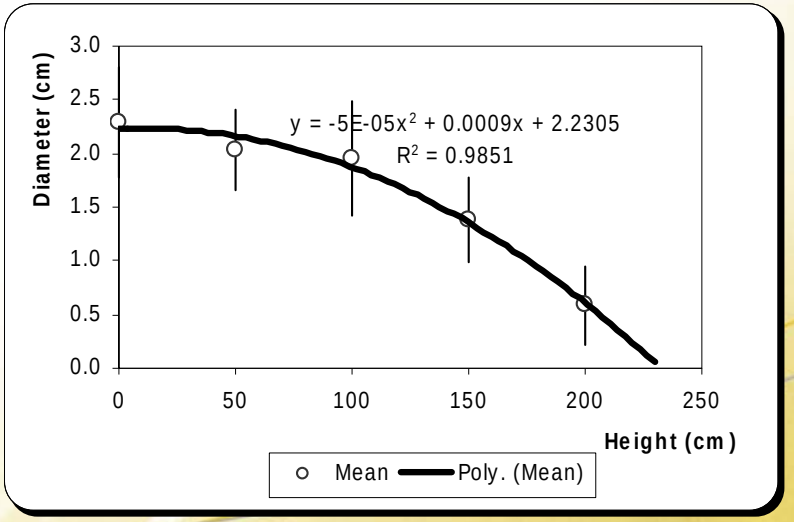
VALERI direct method (for LAI)

- **Direct method**
- **Field harvesting (FH)**

  - ✓ Direct measurement of ‘true’ and effective LAI
  - ✓ A square m² in the centre of an ESU
  - ✓ Depends on harvesting permissions
  - ✓ Comparison of reference ‘true’ and effective LAI with indirect methods

VALERI direct method (for LAI)

ESU:	40			
VEGETATION:	maize			
SAMPLED SURFACE		1 m²		
NR OF SUBPLOTS		1		
PAI	3.6			
LAI	3.3			
GREEN L	BROWN L	STEMS	FRUITS	TOTAL
33299		2490		35789
cm²		cm²		cm²



VALERI Conclusions

- The VALERI sampling strategy can be applied for heterogeneous patchy landscapes (Gilching case).
- The complete VALERI procedure has been applied at the Shandan and Gilching sites. Though both sites are very different at the landscape level, up-scaling to 1 km² pixels in both cases leads to acceptable LAI validation fields.
- Nevertheless, not all landscapes are suitable for the validation of bio-geophysical vegetation variables.
- The base site should be as flat as possible. Hence (very) hilly terrain is excluded.
- Water bodies are unwanted in the base site.


ESU = f(Panorama)
Thanks for your attention
Yellow river